Instructions

MARKER GENERATOR

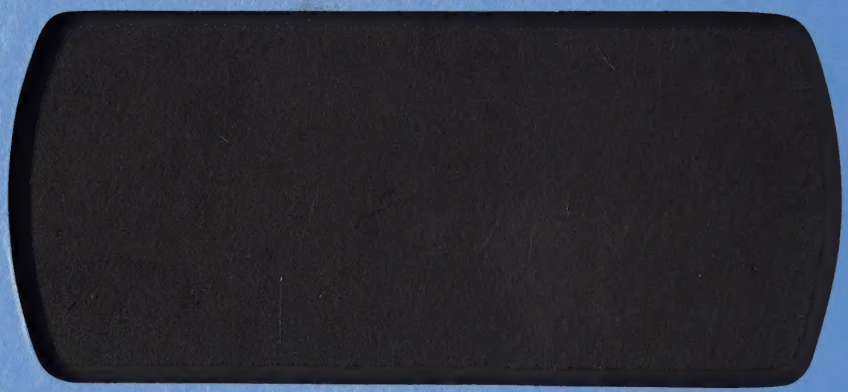
TYPE ST-5A

(Models 4ST5A1, 4ST5A2, and 4ST5A3)

EBI-7007B

MP MASTER
MA32650

GENERAL ELECTRIC



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EBI-7007B

ELECTRONICS DIVISION
GENERAL ELECTRIC COMPANY
ELECTRONICS PARK, SYRACUSE, N.Y.

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USER WARRANTY

The General Electric Company warrents to the purchaser of the new General Electric Marker Generator, Type ST-5A, that any part thereof (except electronic tubes incorporated therein which are covered by the company's standard tube warranties) which proves to be defective in material or workmanship within ninety (90) days from the date of original purchase for use, will be repaired or replaced. Any defect of said Marker Generator, Type ST-5A, should be brought to the attention of the General Electric dealer from whom it was purchased, who shall be authorized to furnish or arrange for repairs or replacements within the terms of this warranty.

The foregoing is in lieu of other warranties, express or implied, and the General Electric Company neither assumes, nor authorizes any person to assume for it, any other obligation or liability in connection with said Marker Generator, Type ST-5A.

CAUTION

The rear of the case is open for ventilation of the equipment. For this reason, the equipment should not be operated with the back of the case tight to the wall.

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These instructions do not purport to cover all details or variations in equipment nor to provide for every possible contingency to be met in connection with installation, operation, or maintenance. Should further information be desired or should particular problems arise which are not covered sufficiently for the purchaser's purposes, the matter should be referred to the General Electric Company.

MARKER GENERATOR

TYPE ST-5A

DESCRIPTION

The General Electric Marker Generator, Type ST-5A, is a precision quality instrument designed to produce highly accurate marker pips to show specific frequency locations on a tuned circuit response curve, when presented on an oscilloscope.

This equipment employs an entirely new approach to the problem of marker generation as applied to wide sweeps. The flexible circuit allows the use of from one to five simultaneous crystal controlled markers, and at the same time permits complete freedom of marker positioning in the 20 to 50 mc band. Further, the equipment furnishes crystal controlled markers for each of the twelve VHF television channels. See APPLICATIONS, subsection 9 for use on UHF channel frequencies.

The tuneable marker ranges have individually hand calibrated dials which can be checked with split hair accuracy by zero beating against a 4.5 mc crystal. With the tuning control adjusted to zero beat, the dial can be mechanically adjusted to the marked check point on the scale.

The circuit design of the Marker Generator has been directed to rapid manipulation for efficient servicing, and since its marker output is crystal controlled, it is unequalled for the alignment of FM and Television receivers and production testing.

The ST-5A Marker Generator is intended to be a companion unit of the ST-4A Sweep Generator. It has essentially no RF output. Its markers are not fed through the circuit under test and so there is no marker distortion of the response curve.

By the flip of a single switch, the operator can add, or remove, audio carrier and adjacent channel markers to the picture carrier. In addition, the 4.5 mc marker is independently available for the alignment of television receivers with intercarrier sound.

Used in conjunction with the Sweep Generator, the Marker Generator with its convenient grouping of controls and precision crystal control of markers, makes an alignment team that is unsurpassed.

SPECIFICATIONS

1. PICTURE CARRIER OSCILLATOR

A 15 position, gear driven rotary switch selects any one of the 12 crystal controlled frequencies, or one of the three tuneable ranges covering the intermediate frequencies. The crystal accuracy is 0.02 percent.

Channel	Crystal Fundamental	Picture Carrier	Crystal Harmonic
2	18.416 mc	55.25 mc	3rd
3	20.416 mc	61.25 mc	3rd
4	22.416 mc	67.25 mc	3rd
5	25.750 mc	77.25 mc	3rd
6	20.812 mc	83.25 mc	4th
7	21.906 mc	175.25 mc	8th
8	22.656 mc	181.25 mc	8th
9	23.406 mc	187.25 mc	8th
10	24.156 mc	193.25 mc	8th
11	24.906 mc	199.25 mc	8th
12	25.656 mc	205.25 mc	8th
13	26.406 mc	211.25 mc	8th

2. IF RANGES

20-27 mc - variable
27-37 mc - variable
37-50 mc - variable

NOTE

Crystals at any frequency in the range between 18 and 30 mc may be used on any vacant channel position if desired. Order crystals from the General Electric Company, or a crystal manufacturer completely familiar with the oscillator circuit and the ST-5A.

The dial scales are in 0.2 mc divisions and can be easily interpolated to 50 kc, and provision has been made to correct and check their calibration with a crystal at 4.5 mc intervals. Check points are marked on the dial and a mechanical adjustment allows the entire dial to be moved to coincide with the zero beat points.

A toggle switch for standby operation allows the operator to remove all markers without disturbing the response curve of the circuit under test.

3. CRYSTAL MODULATOR

The crystal in this circuit in the 4ST5A1 is a dual frequency crystal ground to operate at either its fundamental or the third mechanical mode, depending on the tuned circuit selected by a three-position switch.

The 4ST5A2 and 4ST5A3 circuits are the same except that two crystals are used.

Outputs are:

Markers	Accuracy 4ST5A1	Accuracy 4ST5A2, 4ST5A3
4.5 mc (low harmonic) Audio Carrier	0.05%	0.02%
1.5 mc (low harmonic) Adjacent Channel	±2 kc	0.02%
4.5 mc (high harmonic) Dial Calibrate	0.05%	0.02%

A toggle switch for standby operation allows the removal of all markers except the picture carrier.

4. TUBE COMPLEMENT

V1	Oscillator, Picture Carrier Mixer Modulator	12AV7
V2	Sweep Coupling Tube (4ST5A1 and 4ST5A2 only)	6C4
V3	Marker Amplifier	12AU7
V4	Marker Amplifier Superimposing Section	12AU7
V5	Voltage Regulator	0A2
V6	Voltage Regulator	0A2
V7	1.5-4.5 mc Oscillator	6C4
V8	Rectifier	5Y3GT

5. CABLES

Crystal Modulator to Picture Oscillator
Sweep Input to Picture Oscillator
Response from Receiver
Output to Oscilloscope
Sweep Input

6. FUSE

1 ampere, "Slo-blow"

7. PILOT LIGHT

G-E Type 44

8. AMBIENT TEMPERATURE

0 to 40 degrees C.

9. POWER REQUIREMENTS

105-125 volts, 50-60 cycles, 60 watts; the power transformer has a double primary that can be connected for operation on 210-250 volt input.

10. PHYSICAL DIMENSIONS

Height:	10-3/4 inches
Width:	19-1/4 inches
Depth:	10 inches
Weight:	37 pounds

Note: The front panel is slotted for mounting in a standard 19-inch relay rack mount. Six RTMA rack units are required. (Panel dimensions: 10-1/2 by 19 inches.)

FUNCTION OF CONTROLS

See Fig. 1.

1. PICTURE CARRIER SELECTOR SWITCH

The PICTURE CARRIER selector switch (S1A, B) is a 15 position wafer switch whose control is located at the left of the dial window of the operating panel. Electrically, it inserts any one of twelve crystals or three tuneable circuits in the grid circuit of the picture carrier oscillator (1/2 V1). Thus tuneable markers are available from 20 to 50 mc on fundamentals. On the positions marked 2 - 13, crystals generate markers for the picture carrier of the indicated channel.

2. PICTURE CARRIER ON-OFF SWITCH

The PICTURE CARRIER ON-OFF switch (S5) is a single pole, double throw switch mounted beneath the PICTURE CARRIER selector switch. When turned OFF, it removes the regulated B+ from the PICTURE CARRIER oscillator tube (1/2 V1) and substitutes a dummy resistive load to prevent change in regulation.

3. ADJUST DIAL CONTROL

ADJUST DIAL vernier is located to the right of the PICTURE CARRIER ON-OFF switch on the panel. It actuates a screw type mechanism that allows the dial plate to move about the tuning control shaft axis. Therefore, it is possible to shift the dial scale to correspond to any of the pre-calibrated check points on the dial scale.

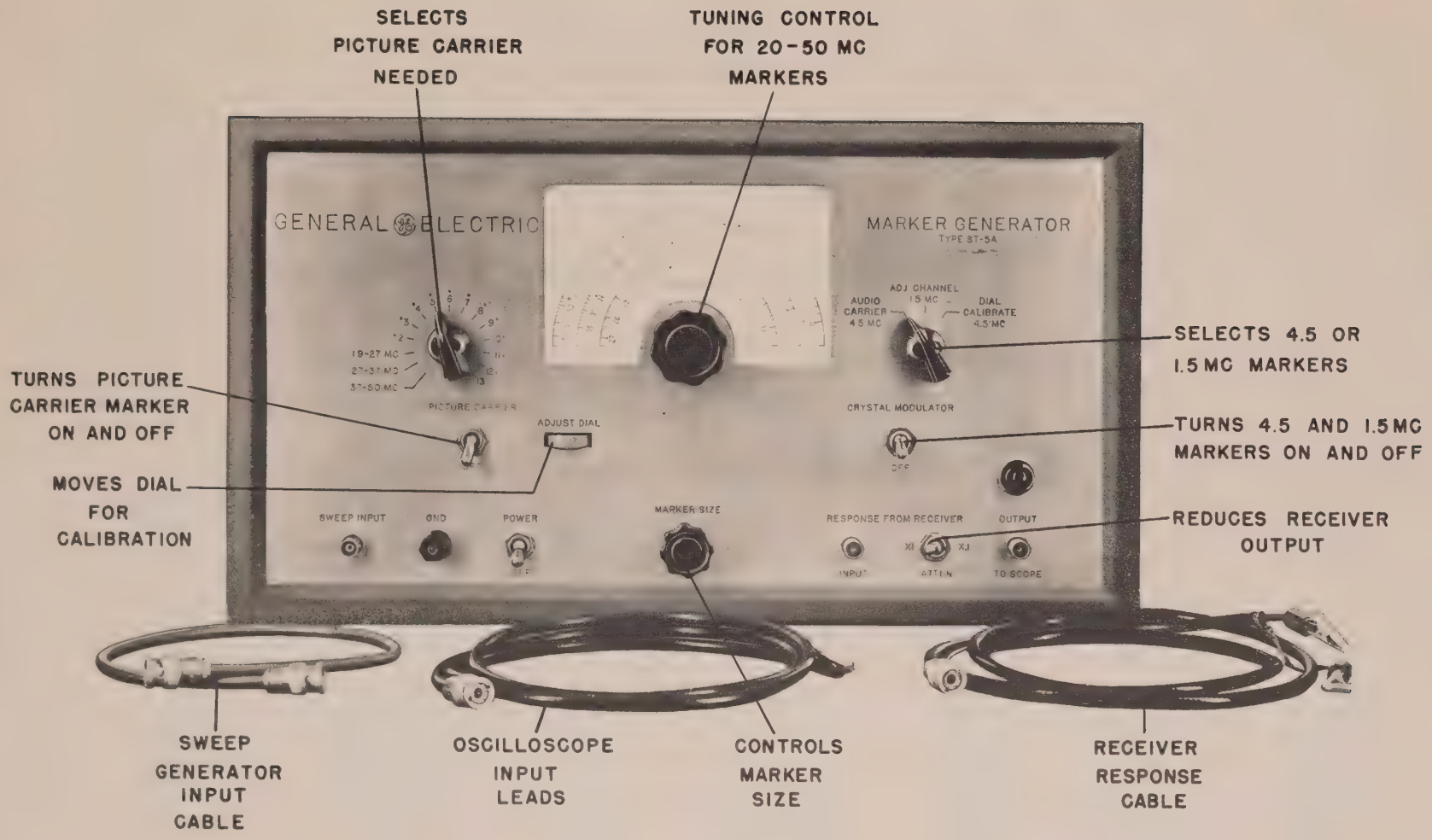


Fig. 1 Front View, Marker Generator, Type ST-5A (SY10041A)

4. POWER SWITCH

POWER switch (S4) is a single pole, single throw switch found at the lower left side of the panel. Electrically it is wired into the primary of the power transformer and opens the circuit in the OFF position.

5. PICTURE CARRIER TUNING CONTROL

Picture carrier tuning control is located immediately below the dial window on the panel. It controls the variable capacitor (C4) to provide the 3 ranges of tuneable markers.

6. MARKER SIZE CONTROL

MARKER SIZE control (R15) is located directly beneath the tuning knob. It is a 50,000-ohm potentiometer in the grid circuit of the marker amplifier (1/2 V4), allowing complete control of the marker output amplitude.

7. CRYSTAL MODULATOR SELECTOR SWITCH

CRYSTAL MODULATOR selector switch (S2) is a three position wafer switch located to the right of the dial window. Electrically it is wired into the plate circuit of the crystal modulator (V7). It inserts suitable values of capacity and inductance to produce outputs of 1.5 and 4.5 mc from the crystal oscillator.

8. CRYSTAL MODULATOR ON-OFF SWITCH

CRYSTAL MODULATOR ON-OFF switch (S3) is a single pole, double throw switch that removes B+ from the crystal oscillator and substitutes a dummy resistor load to prevent load change on the power supply.

9. RESPONSE FROM RECEIVER ATTENUATOR SWITCH

RESPONSE FROM RECEIVER attenuator switch (S6) is a single pole, double throw switch located in the lower right corner of the panel. When switched to the left there is no signal loss. When switched to the right, the output to the oscilloscope is reduced to one tenth of the input from the receiver, thus preventing overload to the super-imposing tube.

THEORY OF OPERATION

The Marker Generator, Type ST-5A, employs two oscillators, a modulator, a three stage amplifier, and two mixing stages to produce markers necessary to the alignment of FM and Television receivers.

The Block Diagram, Fig. 2, shows the general circuit layout of the equipment. It will be noticed that there is no RF output from the generator. The markers are not introduced into the receiver, but superimposed on the receiver output. Therefore, there is no distortion of the response curve and trap circuits can be tuned without losing the markers.

1. PICTURE CARRIER OSCILLATOR (1/2 V1)

The picture carrier oscillator comprises one half of 12AV7 tube. It is a modified Colpitts type with a 15 position gang switch providing the means of switching any one of twelve crystals or three tuneable circuits into its grid. For greater frequency stability, the crystal fundamentals are kept low and harmonic outputs are used for the desired picture carrier frequencies. The following list gives the crystal fundamental and harmonic used for each channel:

Channel	Crystal Fundamentals	Picture Carrier	Crystal Harmonic
2	18.416 mc	55.25 mc	3rd
3	20.416 mc	61.25 mc	3rd
4	22.416 mc	67.25 mc	3rd
5	25.750 mc	77.25 mc	3rd
6	20.812 mc	83.25 mc	4th
7	21.906 mc	175.25 mc	8th
8	22.656 mc	181.25 mc	8th
9	23.406 mc	187.25 mc	8th
10	24.156 mc	193.25 mc	8th
11	24.906 mc	199.25 mc	8th
12	25.656 mc	205.25 mc	8th
13	26.406 mc	211.25 mc	8th

The output of the picture carrier oscillator is taken from the cathode and fed to the grid of the mixer modulator tube (1/2 of V1).

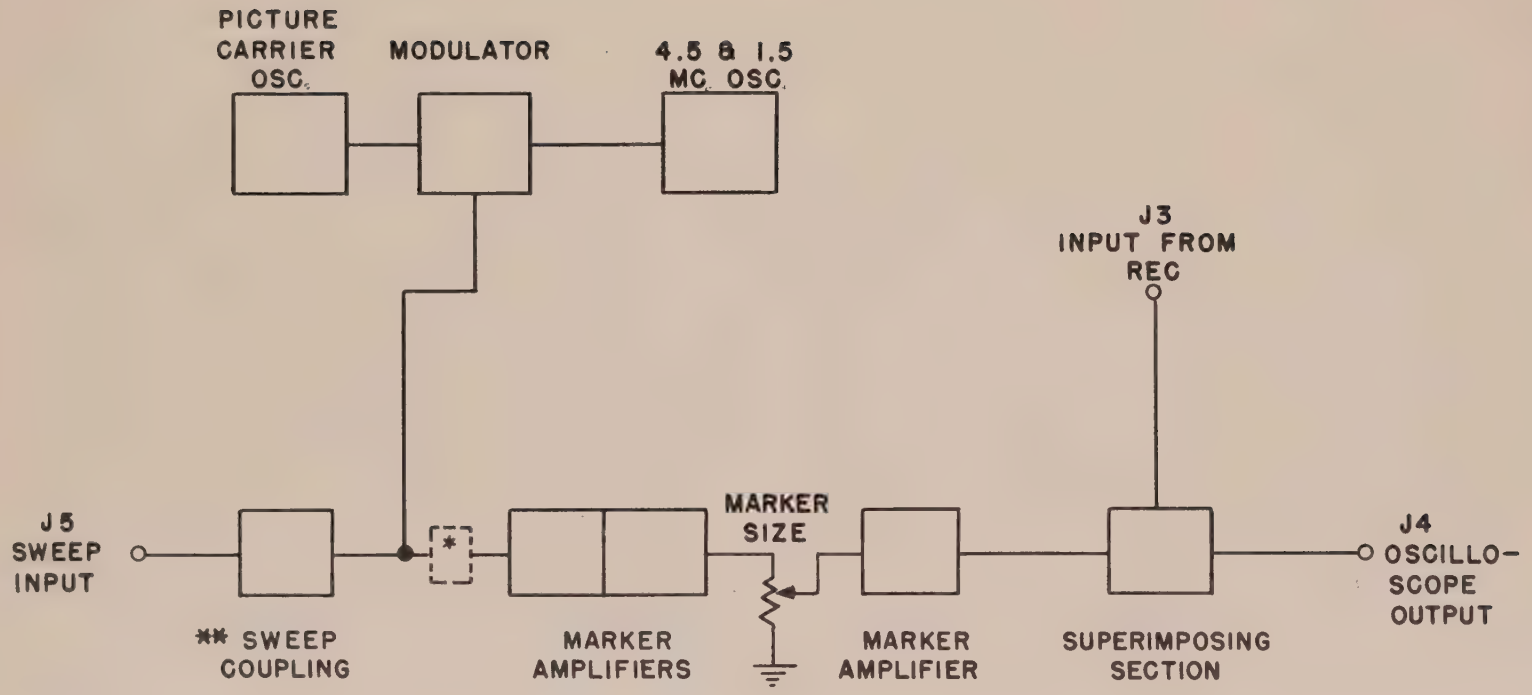
2. SWEEP COUPLING TUBE (V2) (Models 4ST5A1 and 4ST5A2 only)

On the Models 4ST5A1 and 4ST5A2 a sample of the sweep generator output is cabled to the Marker Generator. This voltage is applied to the grid of the sweep coupling tube, V2. The output of the tube is fed from the cathode to the cathode of the mixer modulator stage through C35. (See the Elementary Diagram, Fig. 5.)

3. MIXER MODULATOR TUBE (1/2 V1)

On the Model 4ST5A3 the sweep output is fed directly to the cathode of the mixer modulator tube. (See the Elementary Diagram, Fig. 6.) On the Models 4ST5A1 and 4ST5A2 it is coupled by means of the cathode follower, V2. (See paragraph 2 above.)

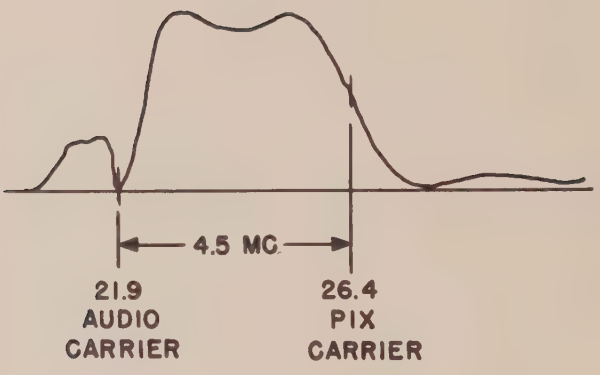
Since the mixer modulator grid is being driven by the picture carrier oscillator across a large value grid resistor, it is biased to the nonlinear portion of its operating curve. Thus, the tube acts as an untuned detector and demodulates the combined signals applied to it. This output appears at the plate load resistor and is taken off through C13 to the grid of the first marker amplifier stage, V3.



*ELECTRICALLY THE MODULATOR TUBE ACTS AS AN UNTUNED DETECTOR IN THE CIRCUIT.

**MODELS 4ST5A1 AND 4ST5A2 ONLY.

Fig. 2 Block Diagram



A

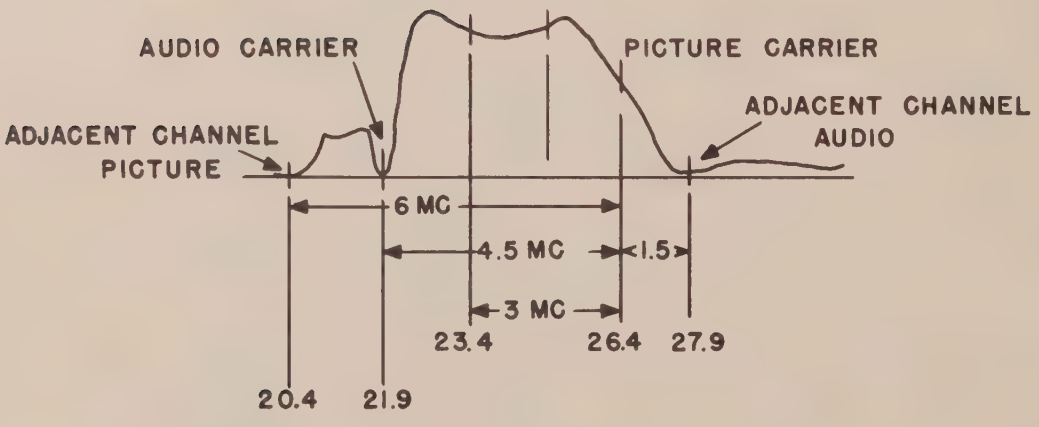


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Fig. 3 Relationship of Marker Pips to Video Response Curves

4. MARKER AMPLIFIERS (V3 AND 1/2 V4)

The three-stage marker amplifier has been designed to give almost no response to a 60-cycle square wave. This is necessary because, when blanking is used, the sweep operates only during the trace period and is turned off for the retrace period. Therefore, the detected output level shifts at the sweep rate of 60 cycles. By selecting low values of grid resistors and small coupling capacitors, no shift of level is found. To sharpen the marker pips, the resistor-capacitor network, C19 and R13, is inserted in the grid of the second stage.

Control of the marker amplifier output is accomplished by the MARKER SIZE control, wired into the grid circuit of the last marker amplifier. The output of the final marker amplifier tube is fed to the cathode of the superimposing section.

5. SUPERIMPOSING SECTION (1/2 V4)

The output of the receiver being aligned is connected to J3 which injects the signal on the grid of the superimposing section. The detected marker signals are fed to the cathode of the same tube and the combined output appears at J4 to be transferred to the vertical input of the test oscilloscope. The receiver response may be reduced to one tenth of its value by turning the attenuator switch, S6.

6. 4.5 AND 1.5 MC OSCILLATOR (V7)

In the 4ST5A1 the crystal used in the crystal oscillator grid circuit is a triplex cut and normally oscillates at 4.5 mc. By changing the plate tuning, it will also oscillate at 1.5 mc. The plate load switching is done with the CRYSTAL MODULATOR selector switch (S2). B+ can be removed by actuating the CRYSTAL MODULATOR ON-OFF switch (S3). The operation of the 4ST5A2 or the 4ST5A3 is the same except that two crystals are used and the grid is also switched.

The output of the crystal modulator is fed to the plate of the modulator tube (V1) where it plate modulates the picture carrier oscillator output, producting sideband markers ±4.5 mc from the picture carrier to show the relation of picture carrier to audio carrier. See Fig. 3A. In the 1.5 mc position, markers are produced every 1.5 mc across the response curve, allowing the operator to check adjacent channel response and band pass characteristics. See Fig. 3B.

7. POWER SUPPLY

The power supply is a conventional full wave rectifier circuit employing a 5Y3GT tube whose output is fed to a smoothing filter composed of C33A, B, C, L5, and R26. The plate voltage of the picture carrier oscillator, the last marker amplifier, and the superimposing section is regulated by the voltage regulator tubes V5 and V6 to prevent undesirable effects of varying line voltage.

The power transformer, T1, has a double winding so that the equipment can be used on 105-125 volts or 210-250 volts, 50-60 cycle power. The MAINTENANCE section shows the simple wiring change to convert to 210-250 volt operation. The equipment is wired at the factory for 105-125 volt power.

APPLICATIONS

1. GENERAL

Inasmuch as the ST-5A Marker Generator has no intentional RF output, it is not directly useable with Sweep Generators other than the ST-4A.

Actually, it is possible to get some RF from the SWEEP INPUT jack if the ST-4A is not connected to it. The level is too low to be useable for most applications. This output level can be raised considerably by interchanging the grid and cathode connections of the sweep coupling tube V2. Note that there will be no control of the output level unless an external attenuator is provided. This is offered as possibly useful information for engineers who might be considering the use of the ST-5A Marker Generator for some specialized application.

Since the ST-5A was designed for use with the ST-4A Sweep Generator, the user is referred to the Sweep Generator instruction book, EBI-7008, for instructions on the combined uses of the equipments for visual alignment of FM and television receivers.

2. CALIBRATION OF THE TUNEABLE RANGES OF THE MARKER GENERATOR

NOTE

For completely stable operation of the Marker Generator, it should be warmed up for a period of at least thirty minutes.

A. Calibration at 27 mc

1) Marker Generator output connected to an oscilloscope.

2) PICTURE CARRIER selector switch to 20-27 mc.

3) PICTURE CARRIER switch to ON.

4) MARKER SIZE control as needed.

5) CRYSTAL MODULATOR selector switch to DIAL CALIBRATE - 4.5 mc.

6) CRYSTAL MODULATOR switch to ON.

7) Oscilloscope VERTICAL GAIN as needed.

8) Tune the output of the tuneable PICTURE CARRIER oscillator for zero beat with the sixth harmonic of the 4.5 mc crystal oscillator (27 mc). Leave the TUNING control in this position. Move dial mechanically with the ADJUST DIAL control so that 27 on the dial matches the pointer position. This matches the upper portion of the dial for very accurate direct reading.

B. The calibration points on the three ranges of the tuneable bands are marked on the dial with red dots. They are as follows:

*20.25 mc	36.0 mc
22.50 mc	40.5 mc
27.00 mc	45.0 mc
31.50 mc	49.5 mc

3. THE IDENTIFICATION OF SPURIOUS MARKERS

When using the BEAT output of the ST-4A Sweep Generator there are points where spurious markers are generated. They will be found at the following points:

A. Intermediate frequencies slightly higher than 27 mc.

B. Channel 2 - only occasionally.

C. Channel 3 - one spurious with the AUDIO marker.

D. Channel 4 and 6 - always present.

These spurious markers only appear when using the BEAT output of the Sweep Generator. To identify the correct markers, follow this procedure:

A. Tune the BEAT OSCILLATOR (not the SWEPT OSCILLATOR) slightly. Markers that retain their positions on the response curve, are the desired markers.

B. Use the PICTURE CARRIER marker first, get it located properly and identified, then use the sideband markers if desired.

4. DETERMINATION OF LOW- AND HIGH-FREQUENCY SIDES OF THE RESPONSE CURVE

In visual alignment procedures it is conventional to place the low-frequency side of the displayed curve to the left side of the oscilloscope.

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*This one is rather weak (turn up MARKER SIZE control). We are actually checking the second harmonic of 20.25 mc against the ninth harmonic of the 4.5 mc crystal at 40.5 mc. The calibration procedure outlined in A. is followed in each case.

Due to the fact that the Sweep Generator has facilities for changing the phase of the oscilloscope horizontal sweep voltage more than 360 degrees, the response curve can be reversed.

The following procedure will establish which side of the displayed curve is the low-frequency side.

A. Tune the Sweep Generator to a slightly HIGHER frequency.

B. Observe the direction of movement of the response curve. It will move toward the low-frequency side.

C. If the curve is reversed (low-frequency at the right), turn the PHASE REVERSAL switch on the Sweep Generator and recenter curve.

5. RELATION BETWEEN PICTURE CARRIER AND AUDIO CARRIER

According to FCC regulations, the transmitter picture carrier and audio carrier are separated by 4.5 mc. By turning on the 4.5 mc CRYSTAL OSCILLATOR, sideband markers are produced on the picture carrier marker to show the correct position of the audio carrier (Fig. 3A). The table below gives the proper control settings of the Marker Generator for commonly desired markers.

CONTROL SETTINGS FOR MARKERS FROM MARKER GENERATOR, TYPE ST-5A

Desired Marker	Band Selector Switch	Picture Carrier Switch	Crystal Modulator Selector	Crystal Modulator Switch	Remarks
4.5	-	OFF	Audio Carrier 4.5	ON	MARKER SIZE control varies marker height.
10.7	20-27	ON	Dial Calibrate	ON*	Calibrate at 22.5 mc, then tune to 21.4 mc.
21.9	20-27	ON	Dial Calibrate	ON*	Calibrate at 22.5 mc.
26.4	20-27	ON	Dial Calibrate	ON*	Calibrate at 27 mc.
Channel 2	Channel 2	ON	Audio Carrier 4.5	OFF	Turn CRYSTAL MODULATOR switch ON when audio carrier marker is needed.

*Switch turned OFF after calibration.

Desired Marker	Band Selector Switch	Picture Carrier Switch	Crystal Modulator Selector	Crystal Modulator Switch	Remarks
Adjacent Channel	Any Channel	ON	Adjacent Channel 1.5	ON	Turning CRYSTAL MODULATOR switch ON adds markers at 1.5 mc intervals, to check adjacent channel response.
43.0	37-50	ON	Dial Calibrate	ON*	Calibrate at 45 mc.
46.0	37-50	ON	Dial Calibrate	ON*	After calibration at 45 mc, tune to 46 mc.
88.0	37-50	ON	Dial Calibrate	ON*	After calibration at 45 mc, this is a second harmonic of 44 mc. Tune to 44 mc.
98.0	37-50	ON	Dial Calibrate	ON*	After calibration at 49.5 mc, tune to 49 mc and use second harmonic.
108.0	27-37	ON	Dial Calibrate	ON*	After calibration at 36 mc, use the third harmonic output.
175.25 mc (Channel 7)	Channel 7	ON	Audio Carrier 4.5	OFF	Turn the CRYSTAL MODULATOR switch ON when audio marker is desired.

6. MARKERS TO SHOW ADJACENT CHANNEL RESPONSE

By turning the CRYSTAL MODULATOR selector switch to the 1.5 mc position, beat pips are produced against the picture carrier at 1.5 mc intervals (Fig. 3B). This allows the operator to check the following characteristics of the response curve:

*Switch turned OFF after calibration.

A. Bandwidth

B. Adjacent channel audio response

C. Adjacent channel picture response

*D. Picture carrier to audio carrier relationship

7. MARKER FOR INTERCARRIER SOUND

By tuning off the picture carrier, the 4.5 mc crystal oscillator is available independently.

8. USING THE MARKER GENERATOR TO CALIBRATE SIGNAL GENERATORS

The ST-5A Marker Generator is inherently more accurate than the majority of signal generators, grid dip meters, and related equipment. Therefore, it serves well as a calibrator of them. The crystals on the tuneable oscillator can be used, either fundamental or harmonic outputs. In general, the tuneable oscillator output is useful up to at least the 6th harmonic of 50 mc (300 mc). The procedure is as follows:

A. Connect the Marker Generator to the oscilloscope as usual.

B. Set the response from receiver switch to X.1 position.

C. Connect the oscillator or generator output to be calibrated to the sweep input jack.

D. Turn the Marker to the desired frequency or band and calibrate scale with internal crystal.

E. Set MARKER SIZE control to approximately mid-position.

F. Adjust equipment being calibrated for a zero beat indication on the oscilloscope. Readjust MARKER SIZE if necessary. Zero beat is an indication that the two oscillators are operating at the same (or harmonically related) frequency. It is the point of no deflection on the oscilloscope. The slightest tuning either way from this point gives a deflection.

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*When using the Model 4ST5A1, it is recommended that the 4.5 mc audio position be used rather than the third harmonic of 1.5 mc for any critical audio adjustments. This is because the crystal tolerances allow a possible error of 2 kc at either 4.5 or 1.5 mc; so, if we use the third harmonic of 1.5 mc it is possible to have an error of 6 kc in the audio marker.

9. USING THE TYPE ST-5-A MARKER GENERATOR AT ULTRA HIGH FREQUENCIES

The Marker Generator can be used in conjunction with the General Electric Type ST-4-A Sweep Generator to provide a single marker in the UHF band. Using sideband markers is confusing because sweep harmonics are being used, and consequently a 1.5 mcs marker would not be 1.5 mcs away from the main marker. Instead, it would be the sweep's harmonic order times 1.5 mc. For example, if the 4th harmonic of the sweep were being used in the 700 mc region, a 1.5 mc marker would actually be 6 mcs separated from the main marker in the same region.

To produce a single marker, such as the picture carrier, in the UHF channel, the best procedure is to use a crystal of a frequency harmonically related to the picture carrier frequency. Harmonic operation is necessary because the oscillator of the marker generator has been designed to operate with crystals within the 18 to 30 mcs region. Also, crystals of higher frequency are expensive and are not obtainable beyond certain frequency limits.

If a marker is desired at the picture carrier frequency of channel 69, a crystal of a fundamental frequency of $\frac{801.25}{28} = 28.62$ mcs could be used. The crystal itself should be plugged into any one of the unused crystal sockets in the Marker Generator. The total number of crystals that can be used is, of course, twelve. The selector switch is marked for channels 2 through 13, but a suitable means (such as a paper sticker) for proper identification of other channels can be devised.

The variable oscillator of the marker may be used in lieu of a crystal, although the accuracy of the marker is not as high. The procedure here is as follows:

A. Divide the desired frequency by the harmonic order of the sweep generator (as being used).

B. Divide this figure by 4 or 5. (In general, if the figure is under 200 mcs, use 4.) Set the marker oscillator to this frequency, and adjust marker size as desired.

For example:

1) Picture Carrier - 530.25 mc

   Harmonic Order of Sweep - 3rd

   $\frac{530.25}{3} = 176.25$ mcs.

2) Frequency of Marker Oscillator - $\frac{176.25}{4} = 44.1875$.

Set the marker oscillator for the 37-50 mcs band, and adjust to 44.1875 mc. (Actually, it would be set so that the pointer is against the low side of the 44.2 mark.)

In the Table of Picture Carrier Frequencies and Generator Settings are listed the proper crystals to be used, (or the proper frequency setting of the variable oscillator), and the proper setting of the sweep dial for all channels above 13, along with the harmonic relationships.

TABLE OF PICTURE CARRIER FREQUENCIES AND GENERATOR SETTINGS

Channel Number	Picture Carrier	Sound Carrier	Sweep Dial	Sweep* Harmonic	Crystal Fundamental	Crystal Harmonic	Marker VFO	VFO Harmonic	Crystal Drawing No.
1									K-113J771
2	55.25	59.75	2	275	18.416	3rd	27.625	2nd	Part 2
3	61.25	65.75	3	275	20.416	3rd	30.625	2nd	3
4	67.25	71.75	4	275	22.416	3rd	33.625	2nd	4
5	77.25	81.75	5	275	25.750	3rd	38.625	2nd	5
6	83.25	87.75	6	275	20.812	4th	41.625	2nd	6
7	175.25	179.75	7	OFF	21.906	8th	43.81	4th	7
8	181.25	185.75	8	OFF	22.656	8th	45.3	4th	8
9	187.25	191.75	9	OFF	23.406	8th	46.8	4th	9
10	193.25	197.75	10	OFF	24.156	8th	48.3	4th	10
11	199.25	203.75	11	OFF	24.906	8th	49.8	4th	11
12	205.25	209.75	12	OFF	25.656	8th	41.05	5th	12
13	211.25	215.75	13	OFF	26.406	8th	42.25	5th	13
14	471.25	475.75	165MC**	3rd	19.635	24th	39.27	12th	14
15	477.25	481.75	165MC**	3rd	19.885	24th	39.77	12th	15
16	483.25	487.75	165MC**	3rd	20.135	24th	40.27	12th	16
17	489.25	493.75	165MC**	3rd	20.385	24th	40.77	12th	17
18	495.25	499.75	165MC	3rd	20.635	24th	41.27	12th	18
19	501.25	505.75	167MC	3rd	20.885	24th	41.77	12th	19
20	507.25	511.75	169MC	3rd	21.135	24th	42.27	12th	20
21	513.25	517.75	171MC	3rd	21.385	24th	42.77	12th	21
22	519.25	523.75	173MC	3rd	21.635	24th	43.27	12th	22
23	525.25	529.75	175MC	3rd	21.885	24th	43.77	12th	23
24	531.25	535.75	177MC	3rd	22.135	24th	44.27	12th	24
25	537.25	541.75	179MC	3rd	22.385	24th	44.77	12th	25
26	543.25	547.75	181MC	3rd	22.635	24th	45.27	12th	26
27	549.25	553.75	183MC	3rd	22.885	24th	45.77	12th	27
28	555.25	559.75	185MC	3rd	23.135	24th	46.27	12th	28
29	561.25	565.75	187MC	3rd	23.385	24th	46.77	12th	29

*On VHF Channels this column refers to the "IF" dial on the ST-4A.
**Sweep width at maximum.

TABLE OF PICTURE CARRIER FREQUENCIES AND GENERATOR SETTINGS

Channel Number	Picture Carrier	Sound Carrier	Sweep Dial	Sweep* Harmonic	Crystal Fundamental	Crystal Harmonic	Marker VFO	VFO Harmonic	Crystal Drawing No.
30	567.25	571.75	189MC	3rd	23.635	24th	47.27	12th	Part 30
31	573.25	577.75	191MC	3rd	23.885	24th	47.77	12th	31
32	579.25	583.75	193MC	3rd	24.135	24th	48.27	12th	32
33	585.25	589.75	195MC	3rd	24.385	24th	48.77	12th	33
34	591.25	595.75	197MC	3rd	24.635	24th	49.27	12th	34
35	597.25	601.75	199MC	3rd	24.885	24th	49.77	12th	35
36	603.25	607.75	201MC	3rd	25.135	24th	40.2	12th	36
37	609.25	613.75	203MC	3rd	25.385	24th	40.6	15th	37
38	615.25	619.75	205MC	3rd	25.635	24th	41.0	15th	38
39	621.25	625.95	207MC	3rd	25.885	24th	41.4	15th	39
40	627.25	631.75	209MC	3rd	26.135	24th	41.8	15th	40
41	633.25	637.75	211MC	3rd	26.385	24th	42.2	15th	41
42	639.25	643.75	213MC	3rd	26.635	24th	42.6	15th	42
43	645.25	649.75	215MC	3rd	26.885	24th	43.0	15th	43
44	651.25	655.75	217MC	3rd	27.135	24th	43.4	15th	44
45	657.25	661.75	219MC	3rd	27.385	24th	43.8	15th	45
46	663.25	667.75	165.8MC	4th	23.687	28th	33.16	15th	46
47	669.25	673.75	167.3MC	4th	23.901	28th	33.46	15th	47
48	675.25	679.75	168.8MC	4th	24.116	28th	33.76	15th	48
49	681.25	685.75	171.3MC	4th	24.330	28th	34.06	15th	49
50	689.25	691.75	171.8MC	4th	24.544	28th	34.36	15th	50
51	693.25	697.75	173.3MC	4th	24.758	28th	34.66	15th	51
52	699.25	703.75	174.8MC	4th	24.973	28th	34.96	15th	52
53	705.25	709.75	176.3MC	4th	25.187	28th	35.26	15th	53
54	711.25	715.75	177.8MC	4th	25.401	28th	35.56	15th	54
55	717.25	721.75	179.3MC	4th	25.616	28th	35.86	15th	55
56	723.25	727.75	180.8MC	4th	25.830	28th	36.16	15th	56
57	729.25	733.75	182.3MC	4th	26.044	28th	36.46	15th	57
58	735.25	739.75	183.8MC	4th	26.258	28th	36.76	15th	58
59	741.25	745.75	185.3MC	4th	26.473	28th	37.06	15th	59
60	747.25	751.75	186.8MC	4th	26.687	28th	37.36	15th	60

*On VHF Channels this column refers to the "IF" dial on the ST-4A.

TABLE OF PICTURE CARRIER FREQUENCIES AND GENERATOR SETTINGS

Channel Number	Picture Carrier	Sound Carrier	Sweep Dial	Sweep* Harmonic	Crystal Fundamental	Crystal Harmonic	Marker VFO	VFO Harmonic	Crystal Drawing No.
61	753.25	757.75	188.3MC	4th	26.901	28th	37.66	15th	Part 61
62	759.25	763.75	189.8MC	4th	27.116	28th	37.96	15th	62
63	765.25	769.75	191.3MC	4th	27.330	28th	38.26	15th	63
64	771.25	775.75	192.8MC	4th	27.544	28th	38.56	15th	64
65	777.25	781.75	194.3MC	4th	27.758	28th	38.86	15th	65
66	783.25	787.75	195.8MC	4th	27.973	28th	39.16	15th	66
67	789.25	793.75	197.3MC	4th	28.187	28th	39.46	15th	67
68	795.25	799.75	198.8MC	4th	28.401	28th	39.76	15th	68
69	801.25	805.75	200.3MC	4th	28.616	28th	40.26	15th	69
70	807.25	811.75	201.8MC	4th	28.830	28th	40.56	15th	70
71	813.25	817.75	203.3MC	4th	29.044	28th	40.86	15th	71
72	819.25	823.75	204.8MC	4th	29.258	28th	41.06	15th	72
73	825.25	829.75	206.3MC	4th	29.473	28th	41.36	15th	73
74	831.25	835.25	208.8MC	4th	29.687	28th	41.66	15th	74
75	837.25	841.75	209.3MC	4th	29.901	28th	41.96	15th	75
76	843.25	847.75	210.8MC	4th	26.351	32nd	42.26	15th	76
77	849.25	853.75	212.3MC	4th	26.539	32nd	42.56	15th	77
78	855.25	859.75	213.8MC	4th	26.726	32nd	42.86	15th	78
79	861.25	865.75	215.3MC	4th	26.914	32nd	43.16	15th	79
80	867.25	871.75	216.8MC	4th	27.101	32nd	43.46	15th	80
81	873.25	877.75	218.3MC	4th	27.289	32nd	43.76	15th	81
82	879.25	883.75	219.8MC	4th	27.476	32nd	44.06	15th	82
83	885.25	889.75	221.3MC	4th	27.664	32nd	44.36	15th	83

*On VHF Channels this column refers to the "IF" dial on the ST-4A.

MAINTENANCE

CAUTION

The dial scales of the tuneable ranges of the Marker Generator are individually hand calibrated. In the case of repairs involving the replacement of the tuning capacitor, it is recommended that the entire instrument be returned to the General Electric Company, Commercial Equipment Division, Syracuse, New York, for repair and recalibration.

1. ADDING CHANNEL CRYSTALS

New picture carriers may be added as channels are assigned in the operating area. No adjustments are necessary to the picture carrier oscillator circuit. A crystal for the proper channel is obtained from the General Electric Company, and inserted in the proper channel crystal socket.

To add new crystals, use the following procedure:

A. Remove screws holding top of cabinet.

B. Remove top of inner compartment.

C. Insert crystal in proper socket.

D. Replace inner shield and cabinet top.

2. REPLACING TUBES

A. Remove top of outer case. V3, V4, V5, V6, and V8 are now available.

B. Remove oscillator inner shield cover to replace V1 and V2.

C. Remove the small shield on the crystal modulator, located to the rear of the chassis behind the rectifier V8, to replace the crystal modulator tube, V7.

3. CRYSTAL MODULATOR ADJUSTMENTS.

In the event that L6 or L7 is replaced, it is necessary that they be adjusted according to the following procedures:

A. Adjusting L7.

1) CRYSTAL MODULATOR switch 4.5 mc AUDIO position.

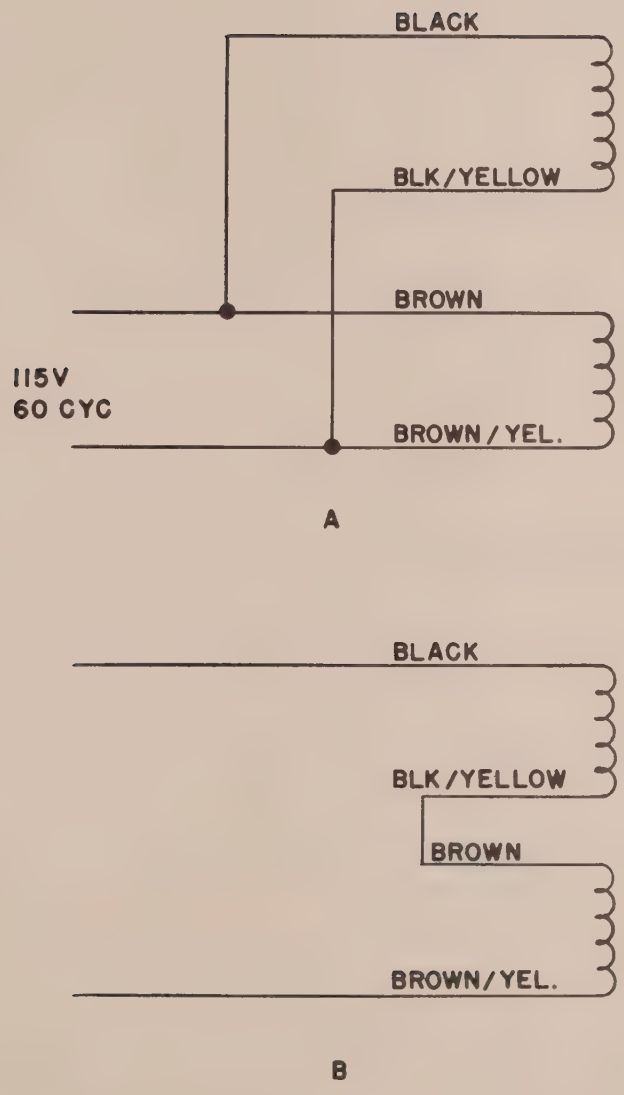


Fig. 4 Wiring Connections for Operation on 230 Volts

2) Connect a good vacuum tube voltmeter, with an isolating resistor of 500,000 ohms in series with its lead, across R27.

3) Turn slug all the way out (minimum inductance).

4) Adjust slug of L7 for maximum voltage across R27, about 30 to 40 volts, and then back off slug until voltmeter reads 20 volts.

5) Tighten locking nut on coil.

B. Adjusting L6

1) CRYSTAL MODULATOR switch 1.5 mc ADJ CHANNEL.

2) Vacuum tube voltmeter across R27 as in L7.

3) Turn slug all the way out, then adjust for maximum voltage across R27.

4) Back off slug until reading is 12 volts.

C. Checking the CALIBRATE position

With the CRYSTAL MODULATOR switch in the 4.5 mc CALIBRATE position, the reading of the voltage across R27 should be approximately 50 volts.

4. OPERATION ON 230 VOLTS

See Fig. 4.

The power transformer of the ST-5A Marker Generator has two primary windings which are wired in parallel for 117-volt operation at the factory, Fig. 4A.

If the generator is to be used on 230-volt power, Fig. 4B shows the simple change to be made.

5. ADJUSTMENT TO MINIMIZE SPURIOUS MARKER

If the oscillator-mixer tube, V1, is replaced (or as a result of tube ageing) it may be necessary to readjust potentiometer R34. This potentiometer is connected as a rheostat in series with the B+ to the oscillator, and hence controls the vigor of oscillation. If a spurious birdie is present (particularly near 44 mcs or channel 6), increase the resistance of the rheostat until the level of the spurious birdie is no more than 1/3 as large as the desired marker. Reduction to more than this ratio may make the birdie size on high channels (7 through 13) too small for satisfactory use.

SOCKET VOLTAGE DATA

All voltages measured from pin to chassis.
DC voltages measured with a 20,000 ohm/volt meter.
AC voltages measured with a 1,000 ohm/volt meter.

V1 Pin	
1	67
2	-.35
3	.2
4	5.8 a-c
5	5.8 a-c
6	143
7	-.4
8	0
9	0

V2 (4ST5A1 and 4ST5A2 only) Pin	
1	163
2	0
3	5.8 a-c
4	0
5	163
6	0
7	4.8

V3 Pin	
1	18
2	0
3	.85
4	6 a-c
5	6 a-c
6	45.5
7	0
8	2.5
9	0

V4 Pin	
1	34
2	0
3	1.25
4	6 a-c
5	6 a-c
6	153
7	31
8	40
9	0

V5 Pin	
1	153
2	-
3	-
4	-
5	-
6	-
7	0

V6 Pin	
1	153
2	-
3	-
4	-
5	-
6	-
7	0

V7 Pin	
1	172
2	0
3	6 a-c
4	0
5	172
6	-.12
7	0

V8 Pin	
1	-
2	320
3	-
4	250 v a-c
5	-
6	250 v a-c
7	-
8	320

PARTS LIST

This list includes all principal replacement parts. The symbol numbers used are the same as those appearing on elementary and other diagrams. When ordering a replacement part, please include description, symbol designation, and reference number of the part and model number of the equipment. Orders may be sent to the nearest General Electric office or to the General Electric Company, Commercial and Government Equipment Department, Electronics Division, Syracuse, New York.

Symbol	Description	G-E Drawing
	CAPACITORS	
C1 thru C3	Variable, air, 2.1 to 14.6 mmfd. Johnson Cat. #15M11.	M-7481115-P3
C4	Variable, air, 6 to 35 mmfd. Hammarlund Type MC-35-S.	P-7769810-P12
*C5 thru C7	Ceramic, 15 mmfd ± 10%, 500 v d-c w. (C6 & C7 in Models 4ST5A1 and 2 only.)	P-3R93-P29
C8	Ceramic, 8 mmfd ± 1 mmfd, 500 v d-c w. (Models 4ST5A1 and 2 only.)	P-3R93-P25
*C9 thru C12	Silver mica, 470 mmfd ± 10%. Erie Type 370CA. (C12 in Models 4ST5A1 and 2 only.)	M-7474000-P10
C13	Ceramic, 1500 mmfd ± 20%, 350 v d-c w. Erie Style L, Hi-K.	M-2R69-P34
C14 and C15	Feed-thru, 0.01 mfd +20% -10%, 600 v d-c w. Sprague Cat. #79P11.	B-7485942-P3
*C16	Mica, 100 mmfd ± 10%, 500 v d-c w. Erie Type 370CB.	M-7471350-P6
C17	Feed-thru, 0.01 mfd +20% -10%, 600 v d-c w. Sprague Cat. #79P11.	B-7485942-P3
*C18	Ceramic, 1500 mmfd ± 20%, 350 v d-c w. Erie Style L, Hi-K.	M-2R69-P34

*This item or equivalent should be obtained from a local radio dealer.

Symbol	Description	G-E Drawing
	CAPACITORS (CONT.)	
*C19	Ceramic, 330 mmfd ± 20%, 350 v d-c w. Erie Style K, Hi-K.	M-2R69-P30
*C20	Ceramic, 100 mmfd ± 20%, 350 v d-c w. Erie Style K, Hi-K.	M-2R69-P27
*C21	Ceramic, 1500 mmfd ± 20%, 350 v d-c w. Erie Style L, Hi-K.	M-2R69-P34
*C22 and C23	Paper, 0.50 mfd +40 -10%, 600 v d-c w.	M-103J768-P38
C24 and C25	RF Filter. Paper, 0.01 mfd +20% -10%, 600 v d-c w. Sprague Cat. #47P6.	M-7479126-P4
*C26	Ceramic, 180 mmfd ± 5 mmfd, 500 v d-c w. Erie Type N330M.	
*C27	Ceramic, 330 mmfd ± 20%, 350 v d-c w. Erie Style K, Hi-K.	M-2R69-P30
C28 and C29	Feed-thru, 0.01 mfd ± 20% -10%, 600 v d-c w. Sprague Cat. #79P11.	B-7485942-P3
*C30 and C31	Silver mica, 1000 mmfd ± 10%. Erie Type 370CA. (C31 in Models 4ST5A1 and 2 only.)	M-7474000-P11
*C32	Silver mica, 6000 mmfd ± 10%, 500 v d-c w. Erie Type 4700-FC.	M-7474948-P1
*C33	Electrolytic, 10-10-10 mfd +50% -10%, 450 v d-c w. Mallory Type FP389.	M-7473661-P8
C34	Ceramic, 2.2 mmfd ± 0.25 mmfd. Erie Type NPOK.	
C35	Ceramic, 1500 mmfd± 20%, 350 v d-c w. Erie Style L, Hi-K.	M-2R69-P34
C36 and C37	Silver mica, 22 mmfd ± 5%, 500 v d-c w. (Model 4ST5A3 only.)	P-3R122-31

*This item or equivalent should be obtained from a local radio dealer.

Symbol	Description	G-E Drawing
	CAPACITORS (CONT.)	
C38	Ceramic, 2.2 mmfd ± 0.25 mmfd. Erie Type NPOK. (Models 4ST5A3 only.)	
	CRYSTALS	
CR1	Crystal, quartz. (4ST5A1 only.)	K-113J767-P1
CR2 thru CR13	Crystals, channel. Specify channel when ordering.	K-113J771
CR14	Crystal, quartz, 1.5 mc. (4ST5A2 and 3 only.)	K-112J715-P1
CR15	Crystal, quartz, 4.5 mc. (4ST5A2 and 3 only.)	K-112J716-P1
	FUSE	
*F1	Slo-blo, 3/4 amp, 250 v, Type 3AG. Littelfuse Cat. #313.750, Bussman Cat. #MDL-3/4.	M-7478924-P8
	INDICATING DEVICE	
*I1	Lamp, 6-8 v, 0.25 amp. G-E Cat. #44.	
	JACKS AND RECEPTACLES	
J1 and J2	Cinch Cat. #81A. (J2 Models 4ST5A1 and 2 only.)	
J3	Connector, Receiver Input. AN Type UG-290/U.	M-7468506-P1
J4	Connector, Output to Scope. AN Type UG-290/U.	M-7468506-P1
J5	Connector, Sweep Input. AN Type UG-291/U.	M-7480736-P1.
	INDUCTORS	
L1	Oscillator coil, inductance 0.90 to 1.15 uh.	K-113J770-P1

*This item or equivalent should be obtained from a local radio dealer.

Symbol	Description	G-E Drawing
	INDUCTORS (CONT.)	
L2	Oscillator coil, inductance 0.45 to 0.60 uh.	K-113J770-P2
L3	Oscillator coil, inductance 0.220 to 0.275 uh.	K-113J770-P3
L4	Cathode choke, inductance 10.5 uh ± 5%.	K-113J772-P1
L5	Filter choke, d-c resistance 370 ohms max.	M-103J75-P1
L6	RF coil, inductance 32 to 46 uh.	K-102J970-P2
L7	RF coil, inductance 4.5 to 7.0 uh.	K-102J970-P1
	RESISTORS	
*R1	Composition, 0.15 megohm ± 10%, 1/2 w. Jan Type RC20BF154K.	
*R2	Composition, 0.82 megohm ± 10%, 1/2 w. Jan Type RC20BF824K.	
R3	Composition, 100 ohms ± 5%, 1/2 w. Jan Type RC20BF101J.	
*R4	Composition, 1000 ohms ± 10%, 1 w. Jan Type RC30BF102K. (Models 4ST5A1 and 4ST5A2 only.)	
*R5	Composition, 82,000 ohms ± 10%, 1 w. Jan Type RC30BF823K.	
*R6	Composition, 27,000 ohms ± 10%, 1/2 w. Jan Type RC20BF273K.	
*R7	Composition, 2200 ohms ± 10%, 2 w. Jan Type RC42BF222K. (Models 4ST5A1 and 2 only.)	
R8	Composition, 100 ohms ± 5%, 1/2 w. Jan Type RC20BF101J. (Models 4ST5A1 and 2 only.)	
*R9	Composition, 47,000 ohms ± 10%, 1/2 w. Jan Type RC20BF473K.	

*This item or equivalent should be obtained from a local radio dealer.

Symbol	Description	G-E Drawing
	RESISTORS (CONT.)	
*R10	Composition, 1800 ohms ± 10%, 1/2 w. Jan Type RC20BF182K.	
*R11	Composition, 0.27 megohm ± 10%, 1/2 w. Jan Type RC20BF274K.	
*R12	Composition, 4700 ohms ± 10%, 1/2 w. Jan Type RC20BF472K.	
*R13	Composition, 47,000 ohms ± 10%, 1/2 w. Jan Type RC20BF473K.	
*R14	Composition, 0.27 megohm ± 10%, 1/2 w. Jan Type RC20BF274K.	
*R15	Potentiometer, composition: 47,000 ohms ± 20%, 1/2 w, linear taper. Chicago Tel. Supply Type 35.	M-2R45-P19
R16 and R17	Wirewound, 2400 ohms ± 10%, 30 w.	K-7113J738-P1
*R18 and R19	Composition, 68,000 ohms ± 10%, 2 w. Jan Type RC42BF683K.	
*R20	Composition, 1500 ohms ± 10%, 1 w. Jan Type RC30BF152K.	
*R21	Composition, 0.15 megohm ± 10%, 1 w. Jan Type RC30BF154K.	
R22	Composition, 47,000 ohms ± 5%, 1/2 w. Jan Type RC20BF473J.	
R23	Composition, 10,000 ohms ± 5%, 1/2 w. Jan Type RC20BF103J.	
R24	Composition, 6800 ohms ± 5%, 1/2 w. Jan Type RC20BF682J.	
R25	Composition, 0.82 megohm ± 5%, 1 w. Jan Type RC30BF824J.	

*This item or equivalent should be obtained from a local radio dealer.

Symbol	Description	G-E Drawing
	RESISTORS (CONT.)	
R26	Wirewound, 2400 ohms ± 10%, 30 w.	K-113J738-P1
*R27	Composition, 47,000 ohms ± 10%, 1/2 w. Jan Type RC20BF473K.	
*R28	Composition, 10,000 ohms ± 10%, 1/2 w. Jan Type RC20BF103K.	
*R29	Composition, 1000 ohms ± 10%, 1 w. Jan Type RC30BF102K.	
*R30 and R31	Composition, 56,000 ohms ± 10%, 2 w. Jan Type RC42BF563K.	
*R32	Composition, 470 ohms ± 10%, 1/2 w. Jan Type RC20BF471K. (Models 4ST5A1 and 2 only.)	
*R33	Composition, 56 ohms ± 10%, 1/2 w. Jan Type RC20BF560K. (Model 4ST5A3 only.)	
R34	Potentiometer, wirewound: 2500 ohms ± 10%, 2 w, linear taper. (Model 4ST5A3 only.)	M-2R72-P62
*R35	Composition, 2200 ohms ± 10%, 1 w. Jan Type RC30BF222K. (Model 4ST5A3 only.)	
	SWITCHES	
S1	Picture Carrier Selector. Rotary switch, 18 point, 4 section.	K-113J736-P1
S2	Crystal Modulator Selector. Rotary switch, 1 section, 2 pole, 3 position. Oak Type H.	B-7408063-P2
*S3	Crystal Modulator On-Off Switch. Toggle type, spdt, 1 amp at 250 v, 3 amp at 125 v. Arrow Hart and Hegeman Type 21350-WJB.	M-7478623-P3
*S4	Power Switch. Toggle type, spst, 3 amp at at 250 v. Arrow Hart and Hegeman Type 20994-WJB.	M-7478623-P1

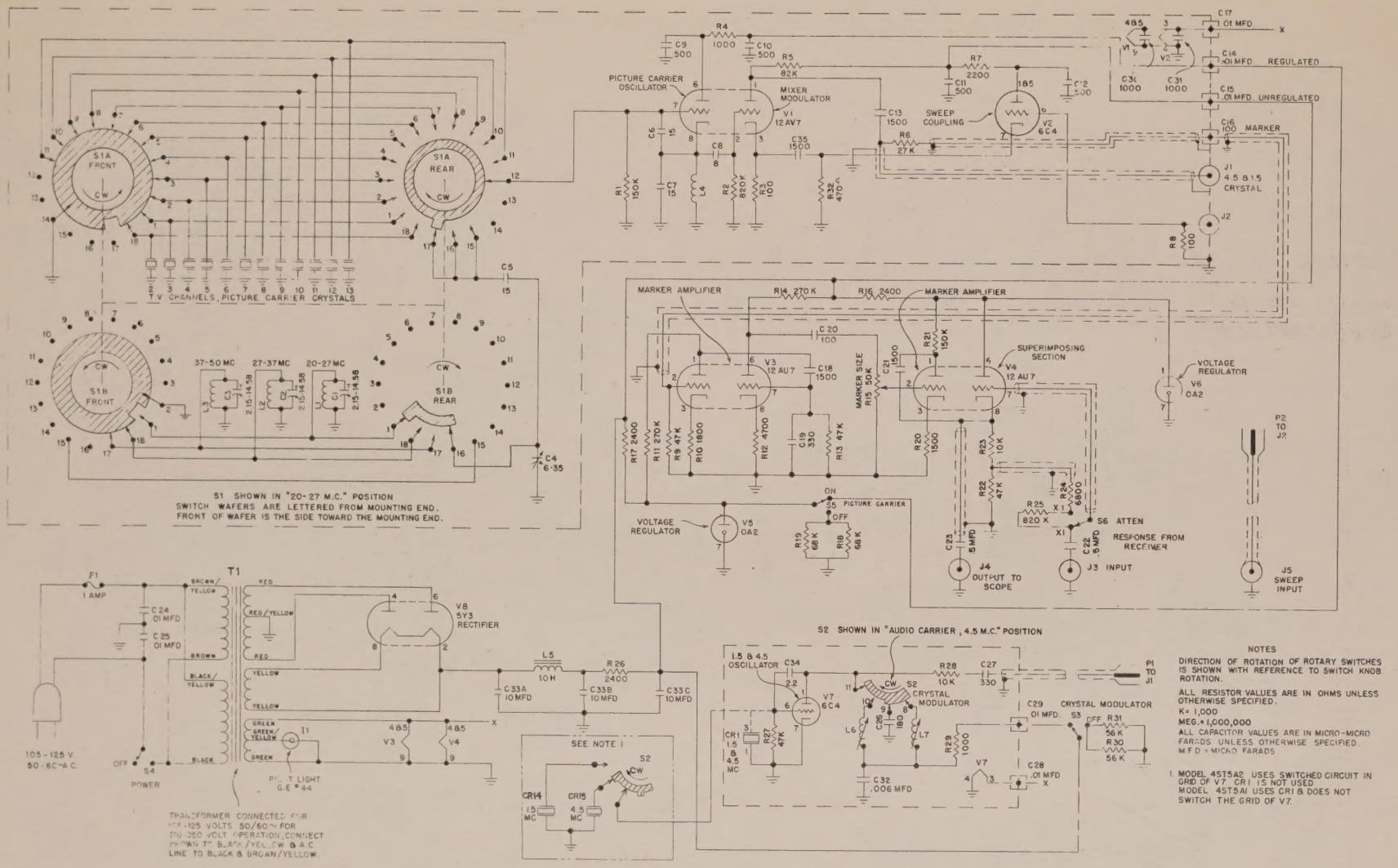
Symbol	Description	G-E Drawing
	SWITCHES (CONT.)	
S5	Picture Carrier On-Off Switch. Same as S3.	
S6	Response from Receiver Switch. Same as S3.	
	TRANSFORMER	
T1	Power transformer.	M-103J531-P1
	TUBES	
V1	Type 12AV7.	
V2	Type 6C4. (Models 4ST5A1 and 2 only.)	
V3	Type 12AU7.	
V4	Type 12AU7.	
V5	Type 0A2.	
V6	Type 0A2.	
V7	Type 6C4.	
V8	Type 5Y3.	
	SOCKET	
*XCR2 thru XVR13	Crystal holders: 2 pin steatite. Type CR-7, H H Eby Cat. #9006.	K-7128948-P1
XCR14	Crystal holder, steatite.	K-7115463-P1
XCR15	Crystal holder: 2 pin steatite. Type CR-7, H H Eby Cat. #9006.	K-7128948-P1
XF1	Fuse holder.	K-113J681-P1
XI1	Pilot light assembly. Drake Type 40, ruby jewel.	

*This item or equivalent should be obtained from a local radio dealer.

Symbol	Description	G-E Drawing
	SOCKETS (CONTINUED)	
*XV1	Tube socket, 9 pin. RTMA Type TSE9T201.	M-7480532-P3
XV2	Tube socket, 7 pin. (Models 4ST5A1 and 2 only.)	M-103J69-P2
*XV3 and XV4	Tube sockets, 9 pin. RTMA Type TSE9T201.	M-7480532-P3
XV5 thru XV7	Tube sockets, 7 pin.	M-103J69-P2
XV8	Tube socket, octal.	K-102J862-P1
	MISCELLANEOUS ITEMS	
	Binding post.	K-107J146-P1
	Bushing.	K-107J973-P1
	Cable, Crystal Modulator to Picture Osc.	ML-113J760-G1
	Cable, Output to Scope.	PL-112J834-G1
	Cable, Response from Receiver.	PL-112J833-G1
	Cable, Sweep Input.	PL-112J835-G2
	Cable, Sweep Input to Picture Osc. (4ST5A1 and 2 only.)	ML-113J756-G1
	Cable, Sweep Input to Picture Osc. (4ST5A3 only.)	ML-7140127-G1
	Dial bracket assembly.	ML-113J649-G1
	Dial drive.	K-102J968-P1
	Dial plate.	K-113J781-P1
	Dial pointer.	K-113J764-P1
	Dial shield assembly.	ML-113J655-G1
	Drive wheel.	K-113J652-P1

*This item or equivalent should be obtained from a local radio dealer.

Symbol	Description	G-E Drawing
	MISCELLANEOUS ITEMS (CONT.)	
	Dial window.	K-113J729-P1
	Gear.	K-112J9-P1
	Gear bracket.	K-102J983-P1
	Knob, Marker size, black. Similar to Kurz Kasch Cat. #S-308-64-B-BB except without pointer.	K-7105373-P1
	Knob, Picture Carrier and Crystal Modulator, black. Kurz Kasch Cat. #S-246-3L.	K-7876700-P2
	Knob, Tuning, black. Kurz Kasch Cat. #S-309-64-B-BB.	K-7003094-P3
	Shaft.	K-113J727-P1
	Spring.	K-113J733-P1



NOTES

DIRECTION OF ROTATION OF ROTARY SWITCHES IS SHOWN WITH REFERENCE TO SWITCH KNOB ROTATION.

ALL RESISTOR VALUES ARE IN OHMS UNLESS OTHERWISE SPECIFIED.
K = 1,000
MEG. = 1,000,000
ALL CAPACITOR VALUES ARE IN MICRO-MICRO FARADS UNLESS OTHERWISE SPECIFIED.
M F D = MICRO FARADS

1. MODEL 4ST5A2 USES SWITCHED CIRCUIT IN GRID OF V7. CR1 IS NOT USED. MODEL 4ST5A1 USES CR1 & DOES NOT SWITCH THE GRID OF V7.

Fig. 5 Elementary Diagram, Marker Generator, Models 4ST5A1 and 4ST5A2 (T-105J256, Rev. 6)

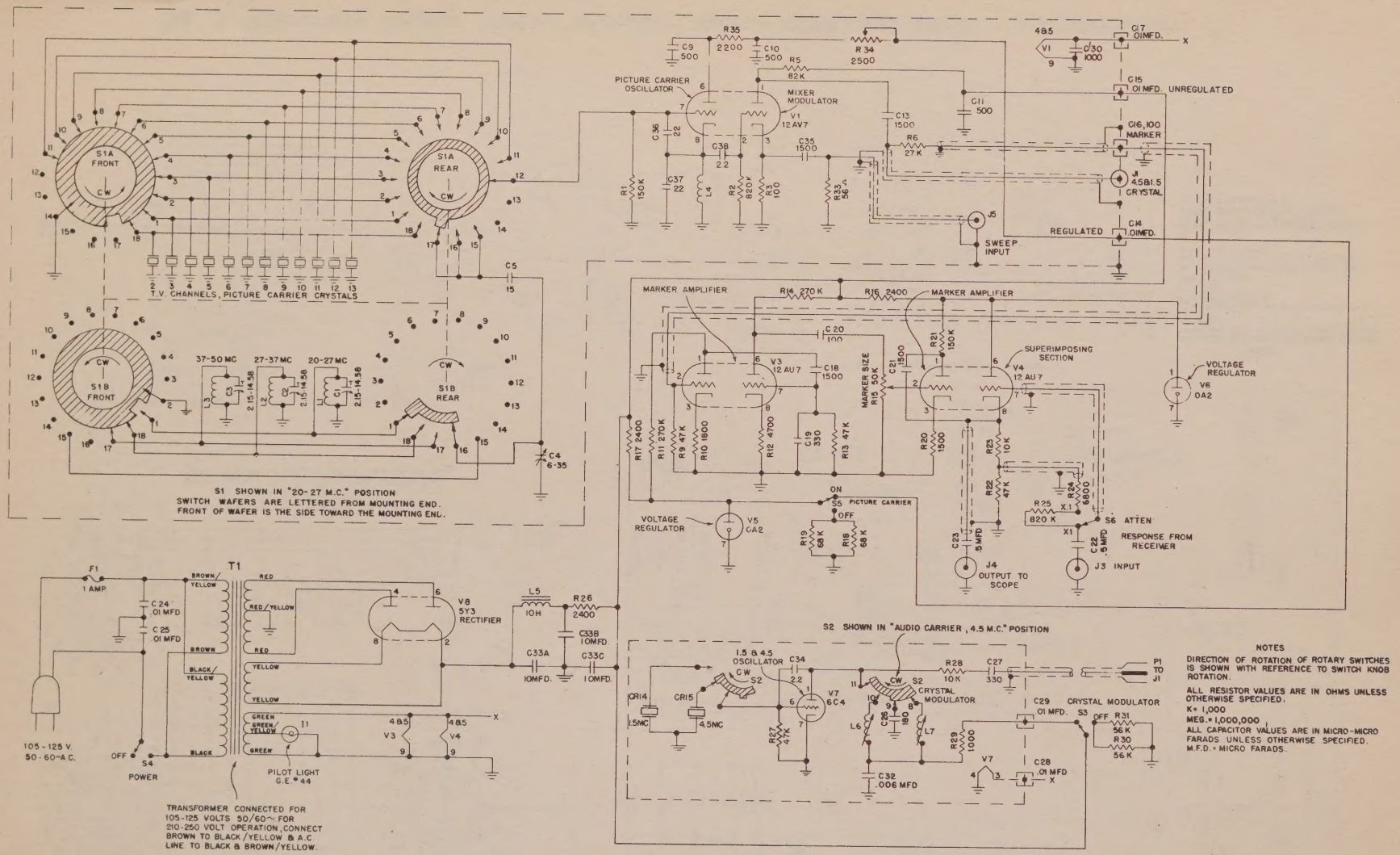


Fig. 6 Elementary Diagram, Marker Generator, Model 4ST5A3 (D-7668316, Rev. 1)

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